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The history of anthrax.

Anthrax has been k n since antiquity as a devastating disease of animals which is transmissible to man. Perhaps we find the oldest indication of this malady in 2 Moses IX, 3 (1250 B.C.), where God sends a dreadful pestilence over the cattle in the field, over horses, asses, camels, oxen and sheep as one of Pharaoh's seven scourges.

Epizootics were considered a form of divine punishment in those days (1); sacrifices and prayers were offered in an attempt to escape them. It is interesting to note that the Jews had recognized the transmissibility of certain diseases, whereas Hippocrates (430 B.C.) makes no reference to the dangers of contagion. He originated the concept of "pathological constitutions," according to which epizootics and epidemics were caused by cosmo-telluric influences (comets, earthquakes, floods) poisoned by miasmata (chemico-dynamic powers, atmospheric toxins). Hippocrates also attributes great significance to atmospheric changes due to the season and climate. The whole of Greek, Roman and Arabic medicine acknowledges this doctrine; other concepts approaching the doctrine of contact transmission did not make an appearance before the Middle Ages.

Dissemination of variola, rabies, typhus and plague, as well as the influx of syphilis in the 16th century, brought new realizations which were systematized by Girolamo Fracastaro (died 1553). He postulated vectors of disease, seminaria prima. In his opinion contagion is transmitted by direct contact, by clothes, furniture, etc. In his words, these items are the "tinder and flint" of epidemic flareups. He also observed that recovery from measles protects against reinfection.

However, these modern-sounding theories were soon lost and did not become subjects of discussion before the advent of Pasteur. When Antonius Leeuwenhoek of Delft discovered countless, very small organisms in pus obtained from his infected tooth under the microscope (he described the various forms of bacteria as we know them today), no-one suspected that these microorganisms were the pathogens of numerous dreaded diseases.

Anthrax (2) was brought to Germany from Italy via France, where it was reported in the 17th century as lingual anthrax. It was mentioned first in 1712, when the lingual form of the disease was seen near Augsburg. The malady subsequently spread throughout Germany and inflicted great losses during socalled anthrax years at the start of the 19th century.

In order to characterize scientific knowledge in the field of anthrax research prior to the discovery of the pathogen, reference is made to Haubner's textbook (3)(1848). He found the characteristics of the disease in its sudden onset, the rapid progression, the peculiar condition of the blood, the gangrenous destruction of certain organs, and in the rapid putrefaction and disintegration of the cadaver. He differentiates between the following forms of anthrax:

a) Anthrax without external, local affection.

1) Apoplectic anthrax (apoplexy or suffocative catarrh, pulmonary gangrene). This form occurs principally in sheep, but also in cattle.

2) Anthracic fever, the usual form of anthrax in cattle and horses.

b) Anthrax with erysipelas, external, gangrenous inflammations and carbuncles.

1) Swine erysipelas (virulent, gangrenous erysipelas). Aside from angina, the usual form of swine anthrax.

2) Swine angina (gangrenous swelling of throat, laryngeal gangrene).

3) Sheep erysipelas (galloping gangrene, black loin). Anthrax-like erysipelas, especially on the loins.

4) Carbuncular disease (carbuncular fever, symptomatic anthrax). In all animals, particularly in cattle and horses.

c) Gangrenous inflammations. Sequential to injuries, especially in sheep.

d) Typhous diseases. Abnormal blood, diseases of the nervous system.

According to Haubner, the disease erupts either sui generis or by infection. He attributes the former to the effect of poorly digestible, pyrogenic feeds such as clover, seeds, slops, to moldy and fungous fodder, stagnant and foul water, to swampy or oily grounds and to sultry air. Such exciting factors as hemal congestion due to heavy work, sunstroke and cold rain were said to trigger the actual outbreak of anthrax. In Haubner's opinion the epizootic spreads by contagion involving moving and fixed infectious substances which include the emanations of sick animals on one hand, and the blood, feces and parts of cadavers, on the other. This infectious substance was said to be contained in the blood as a yellowish, gelatinous fluid, the socalled anthrax material, and was said to be dangerous to all warm-blooded animals and man. He reports that the infectious substance persists for a long time and is not readily destroyed.

Heusinger (4) defended the following concept in 1850: Anthrax is a malarial neurosis in which the malarial toxin initially attacks the ganglionervous system. The principal effect is paralysis of the splenic vessels and necrosis of the spleen. The same vascular paralysis, blood stasis, blood extravasations and gangrene subsequently affect the various organs. A contagium is formed which contributes considerably to dissemination and which acts in the same manner as the original causative agent.

Virchow (5) agreed with Heusinger on the malarial nature, but he blames a specific enzyme for the genesis of anthrax.

A new era in the knowledge of anthrax was opened by the discovery of Pollender (6), who in 1849 made a peculiar observation during blood tests of anthracic cattle. Aside from considerable increase in white blood cells, he found a countless number of rod-shaped, extraordinarily fine, apparently solid, straight, unramified bodies 2.5-5 microns long and 0.3 microns wide. They are absolutely motionless and resemble vibrios in shape and appearance. Their chemical behavior led Pollender to identify them as plants, but he was unable to establish their origin and genesis, nor could he determine whether they existed in living blood or only in postmortal material. It was not clear whether they were a product of fermentation or putrefaction, whether they were the infectious substance, its carrier, or were completely unrelated to the latter. On the basis of chemical factors, Pollender categorically rejected the assumption that the bodies could be pieces of decomposed, primitive fibers, animal fibers, or solid protein compounds as such.

In 1857 Brauell (7), independently of Pollender, found the rod-shaped bodies in the blood of persons, sheep and horses that had succumbed to anthrax. Together with the multiplication of white blood cells, they constituted the most constant change. Brauell called them vibrios that develop in living blood. They are found immediately before and after death, and may thus be evaluated as diagnostic signs in recent cases. In addition, Brauell demonstrated transmission of the contagium from man to sheep. However, since he also produced anthrax with blood not containing rod-shaped bodies, Brauell (8) attributed only diagnostic and prognostic values to them and denied their identity with anthracic toxin or its carrier.

The rod-shaped bodies were evaluated in various ways. While many investigators deemed them blood crystals, fibrinous excretions or tissue detritus, Davaine (9) in 1863 designated them bacteria and later called them bacteridia to distinguish them from motile, putrefactive bacteria. He asserts on the basis of experiments that these bacteridia transmit anthrax; blood without bacteridia was said to be incapable of passing it on to another animal. Bacteridia disappear due to putrefaction; the contagium is preserved by drying and may produce anthrax 4½ months later.

In 1865 Brauell (10) eliminated swine erysipelas from the group of anthrax diseases.

In 1871 F. Cohn (11) defined the nature of bacteria as follows: Bacteria are cells; they multiply by transverse fission and form two equal daughter cells. Divided generations isolate themselves at once or cohere for some time in chains. Assimilation of protein substances and formation of side products is called putrefaction. Bacteria may be classified into spherical or punctate, cylindrical and spiral organisms according to their external characteristics. When nitrogenous nutrients are exhausted, they assume the resting state. Carried off by air, they can once again produce putrefaction. The step toward recognition of bacteria as causative agents of many diseases had not been made yet. Pasteur's assumption (1812-1895) that these microscopic organisms could be the cause of purulence, gangrene and toxemia, had not been acknowledged generally as yet.

Bollinger (12) reports in 1872 that he produced genuine anthrax by injecting rabbits with anthracic blood without rod-shaped organisms, in such a manner that the blood of infected animals contain characteristic anthrax bacteria in life and death. Contrary to Brauell's opinion, who concludes that the bacteria do not represent the anthrax toxin, these results were explained by assuming that anthracic blood in such cases already contains minute forms, bacterial spores, which give rise to the development of bacteria in inoculated animals. Conversely, blood containing anthrax bacteria will produce the disease when injected into another animal, although the blood of the infected animal may not harbor rod-shaped bacteria. Bollinger claims that the clinical and morbid anatomical symptoms of anthrax in domestic animals results from the enormous affinity of anthrax bacteria for oxygen. This effect is said to produce oxygen depletion and a surplus of CO_2 in the blood of sick animals, leading to their death.

In 1876 Robert Koch (13) succeeded in growing anthrax bacteria in pure culture on vitreous humor fluid. The bacteria are fully infective even after the eighth trans-inoculation; the blood of infected and expired white mice may be used for renewed cultivation of anthrax bacteria. Moreover, Koch was the first to observe the process of sporulation in 1878. He established that dried spores remain infective for protracted periods of time and are enormously resistant to external influences. He thus clarified the manner in which anthrax is caused and disseminated.

Bollinger (1875) and Feser (1876) showed the difference between symptomatic anthrax and anthrax on the basis of etiology. In 1877 Pasteur grew an anaerobic bacillus (vibrion septique) from the blood of a dead cow, identified by Chauveau and Arloing (1884) as the pathogen of a dreaded wound infection (septicémie gangréneuse). Meanwhile (1881) Koch injected putrefied fluid into test animals and produced a disease he called malignant edema. He identified its pathogen with Pasteur's vibrion septique. In 1883 Loeffler discovered the pathogen of erysipelas, a disease that had been identified with anthrax until the 1880's. This removed the gas edema diseases and swine erysipelas from the concept of "anthrax."

In 1881 Pasteur obtained active immunity by subcutaneous inoculation of attenuated cultures. Pasteur's original method involves cultivation of virulent anthrax bacilli in broth for 12 or 24 days at 42.5°C.

The pathogenesis of anthrax was studied further. The significance of the capsule in bacillary virulence was recognized. Diagnosis was advanced appreciably by Ascoli's precipitation test (1910). Methods of immunization have been developed further since then. According to Hutyra-Marek's textbook (13), we know today that anthrax is "an infectious disease of septicemic nature, caused by Bacillus anthracis and expressed anatomically by acute swelling of the spleen and by serous-hemorrhagic infiltrations of the subcutaneous and subserous connective tissue."

Wuerttemberg.

In order to make the statistical material more meaningful, I shall briefly discuss the political, geographical and agricultural structure of Wuerttemberg. In addition, cattle stocks and soil utilization are relevant to this study.

Wuerttemberg is a part of the Federated State of Baden-Wuerttemberg and includes the administrative districts North and South Wuerttemberg. This area corresponds to the former Kingdom of Wuerttemberg, including Hohenzollern. Wuerttemberg covers an area of 19,500 km^2.

Originally, Wuerttemberg had been divided into 4 administrative counties (Neckar, Schwarzwald, Jagst and Donau) with 64 superior magistracies. The superior magistracy of Cannstadt was dissolved in 1923, that of Weinsberg in 1926. The administrative reform of 1938 converted the 62 superior magistracies to 3 urban and 34 rural counties.

The county boundaries do not correspond to the four natural regions of which Wuerttemberg is composed. These are the Schwarzwald, the Main-Neckarland, the Schwaebische Alb and the Alpenvorland.

Most of Wuerttemberg's Black Forest is a variegated sandstone region. The primitive rocks are found mainly in Baden. Since the Black Forest extends from north to south, it blocks the westerly winds, which precipitate on its western slope. About 60% of the Black Forest is covered with woods.

The Main-Neckar or Unterland is situated between the Black Forest, Schwaebische Alb and Odenwald. Geologically it is a Kouper-Jura terraced landscape of shell limestone. The strata slope toward the southeast and are grouped into:

a) the provincial plains on both sides of the Neckar (Strohgau, Heckengau, Zabergau, Kraichgau, Hohenloher Ebene); they represent shell limestone; some of the valleys are deep incisions;

b) the Kouper heights (Schoenbuch, Filder, Stromberg, Heuchelberg, Loewensteiner Berge, Schwaebischer Wald), which are already covered by the Black Jura near the foothills.

Precipitation is moderate (under 700 mm), the Unterland is very fertile and maintains a highly developed cattle industry; higher elevations are partially wooded.

The Schwaebische Alb, which extends from southwest to northeast, consists of White Jura on its highlands. In its steep descent to the Neckar it inclines gradually to the Donau, notched by deep transverse valleys. The Alb is an old and karstic region with little water. It is moderately fertile and still has large pastures for sheep.

Oberschwaben, the Wuerttemberg portion of the alpine foothills, is located between the Donau, Iller and Bodensee. Its southern part is a morainic landscape of the ice age, its northern portion is a tertiary landscape with low elevations. The Oberland is fertile and has a well-developed cattle industry.

The Neckar and Donau are the principal drainage arteries of Wuerttemberg; together with numerous tributaries (see Plate V) they form a highly ramified river system.

The table reproduced below lists stocks of domestic animals in Wuerttemberg. Comparison of the various years shows that the number of sheep has declined sharply and that horses have decreased slowly since World War II, while stocks of cattle and swine, although reduced in times of war, are constantly on the rise.

The area of arable land amounted to 1,185,000 ha in 1935, i.e., about 61% of the entire surface. Aside from cultivated land, gardens, hop fields and vineyards, meadows took up 38%, feed plants 9.5%, pastures 3% and fallow land 2% of all arable land.

Livestock in Wuerttemberg in thousands

	horses	cattle	sheep	goats	swine
1883	97	904	550	55	292
1892	102	971	386	70	395
1913	116	1124	228	120	584
1919	96	995	229	131	321
1935	101	1037	182	81	697
1949	97	1025	190	123	604
1953	89	1058	149	105	683

Anthrax in Wuerttemberg

a) Totals of the years 1871-1957.

The first official report involving anthrax dates back to 1837, when the Wuerttemberg yearbook listed the following:

> "Concerning domestic animals, this year was marked by anthrax and angina among swine in many areas; the former also occurred among cattle."

It is obvious that most of the cases among swine must have involved erysipelas, but this venerable citation should not be left unmentioned for this reason. Henceforth it must be remembered that erysipelas and gas edema diseases were not differentiated from anthrax before the 1880s. The numerical data up to 1890 therefore are not necessarily reliable.

Succumbed to anthrax or sacrificed in Wuerttemberg:

	horses	cattle	sheep	goats	swine	Total livestock
1871	RARELY	40	RARELY	RARELY	RARELY	(40)
72		57				(57)
73		34				(34)
74		60				(60)
75		47				(47)
76	-	34	-	-	-	34
77	-	61	-	-	1	62
78	1	40	-	-	1	42
1882	?	?	?	?	?	56
1884	?	?	?	?	?	78
1888	20	402	-	-	-	422
1886	total in Jagst & Schwarzwald Counties					227
89	17	285	-	-	-	302
90	12	268	-	-	-	280
91	7	210	-	-	-	217
92	8	278	-	-	-	286
93	8	233	-	-	-	241
94	7	171	-	-	-	178
95	5	172	-	-	-	177
96	3	247	-	-	-	250
97	3	197	-	-	-	200
98	5	301	-	-	2*	308
99	3	371	-	1	-	375
1900	2	188	-	-	-	190
01	3	174	-	5	-	182
02	1	159	-	1	-	161
03	-	150	-	-	-	150
04	-	162	-	1	-	163
05	-	140	-	-	-	140
06	1	265	-	1	-	267
07	7	228	-	4	1	240
08	2	160	-	-	1	163
09	1	129	-	1	2	133
1910	1	177	-	1	1	180
11	1	230	-	2	-	233
12	5	225	1	2	9	242
13	3	144	-	4	3	154
14	1	143	-	1	29	174
15	1	111	-	1	1	114
16	2	72	-	1	-	75
17	-	81	-	1	-	82
18	-	47	-	-	-	47
19	-	33	-	-	-	33

* and 1 dog

	horses	cattle	sheep	goats	swine	Total livestock
1920	-	28	-	1	-	29
21	2	56	-	1	-	59
22	2	50	-	1	-	53
23	1	87	-	1	1	90
24	-	70	-	-	-	70
25	1	90	-	-	3	94
26	-	39	1	1	1	42
27	1	41	-	1	1	44
28	1	64	-	1	1	67
29	-	47	-	-	-	47
1930	-	27	-	-	-	27
31	-	41	1	-	-	42
32	-	45	-	-	-	45
33	-	27	-	-	-	27
34	-	20	-	-	1	21
35	1	32	-	-	-	33
36	-	13	-	-	-	13
37	-	17	-	-	-	17
38	-	17	-	-	-	17
39	2	27	-	-	-	29
1940	-	4	-	-	-	4
41	-	10	-	-	-	10
42	-	2	-	-	-	2
43	-	3	-	-	-	3
44	-	4	-	-	-	4
45	-	4	-	-	-	4
46	-	3	-	-	-	3
47	-	6	-	-	-	6
48	-	2	-	-	-	2
49	1	11	2	-	1	15
1950	-	5	-	-	-	5
51	1	6	-	-	-	7
52	-	5	-	-	-	5
53	-	6	-	-	-	6
54	-	9	-	-	-	9
55	-	17	-	-	2*	19
56	1	21	-	-	1	23
57	-	16	-	-	-	16

* and 1 cat

A better perspective is offered by the graphic representation of Plate I. It indicates that the number of animals lost to anthrax in Wuerttemberg experienced a sudden rise at the end of the 1880s. While the yearly average had been about 50 fatalities 10 years previously, it now rose to about 250 or about five-fold. Peak values of 300-400 were reached in some years. World War I brought a noticeable reversion; the number sank from 174 in 1914 to 39 in 1920. This was followed by another rise that reached 94 in 1925. From this year on the number of fatalities shows a steady decline until 1948, when 2 animals died of anthrax. The postwar period brought another reversal, and we may assume today that about 15 to 20 animals will be lost or sacrificed annually in Wuerttemberg.

A total of 7,368 animals died of anthrax in Wuerttemberg during the years 1888-1957. This figure is broken down as follows:

7,125	head of cattle	96.71%	of animals lost to anthrax
143	horses	1.94%	"
34	goats	0.46%	"
5	sheep	0.07%	"
61	hogs	0.82%	"

In addition, the death of one dog and one cat was reported.

Contrary to the opinion that sheep, cattle, horses and goats contract anthrax most frequently under natural conditions, while swine are infected only upon severe exposure (13), statistics show that considerably more goats than sheep died during 1888-1957 and that both figures are exceeded by the number of hogs. This fact may be explained in part by the assumption that not all anthracic sheep were reported.

The total holdings in the various animal species in Wuerttemberg must be considered in this connection. Anthrax claimed the following number of animals per 100,000:

	horses	cattle	sheep	goats	swine
in Germany 1886-1918 average	2.0	15.0	2.5	0.2	3.0
in Wuerttemberg 1888-1918 average	3.7	19.2	-	-	-
1892	7.9	28.6	-	-	-
1913	2.6	12.8	-	3.3	0.5
1919	-	3.3	-	-	-
1935	1.0	2.9	-	-	-
1949	1.0	1.1	-	-	-

Thus losses due to anthrax in Wuerttemberg during 1888-1918 were 21% higher than the average for all of Germany. The ratio of cattle to horses fluctuates between 7:1 and 1:1, average 5:1.

Since these data were compiled mainly from files of the Central Fund of Livestock Owners, Stuttgart, which pays a compensation for every head of cattle and every horse lost to anthrax, and since no other quantitative data are available, the number of infections could not be established. The latter should not be much higher than the number of expired animals, since anthrax is 96-97% lethal (2) and many animals are destroyed on suspicion (compensation is paid also in the latter case). Slight inaccuracies in the numerical data do not affect the following considerations appreciably.

b) Anthrax in individual counties or superior magistracies and its dependence upon the geographical structure.

Plates II to IV offer a general view. Three time periods, characteristic of the history of anthrax in Wuerttemberg, have been singled out:

Plate II : 1909-1911 (annual average about 180 cases)
Plate III: 1924-1938 (annual average about 40 cases)
Plate IV : 1939-1957 (annual average about 10 cases)

Comparison of maps suggests that in the past anthrax had been distributed nearly throughout the whole state, and that it became concentrated in certain counties during the decades. The counties which, incidentally, have always had a high incidence, are Marbach, Backnang, Heilbronn, Urach, Reutlingen, Balingen, Tuttlingen, Ellwangen, Waldsee and, especially since 195[illegible], Goeppingen.

On the other hand, there are counties in which anthrax has been practically unknown for decades. They are Rottweil, Spaichingen, Sulz, Freudenstadt, Nagold, Neuenbuerg, Vaihingen, Maulbronn, Ravensburg, Laupheim, Schwaebisch Gmuend.

When the geographical structure of the state is considered, it becomes apparent that, with few exceptions, anthrax occurs principally along the medium-sized and larger rivers. As shown by Plates V to VIII, this occurs mainly on

the Murr and Neckar below Backnang as far as the Heilbronn area,
the Echaz and Erms below Reutlingen and Metzingen, respectively,
the Schmiecha below Ebingen,
the Donau below Tuttlingen and Riedlingen,
the Jagst below Ellwangen,

that is, in places where almost every spring and fall the rivers leave their beds and flood the valley meadows in spite of flood control measures taken since the middle of the 1930s. In contrast, the highlands of the Schwaebisch Alb, the Black Forest, the Schwaebisch Forest and Schoenbuch are nearly free of anthrax.

c) Anthrax in man.

According to Hutyra-Marek (13), anthrax usually occurs as a local infection of the skin and subcutis (carbuncle, pustula maligna), especially in persons dealing with sick or expired animals, e.g., veterinarians, butchers, skinners and others; also in workers engaged in the processing of animal hides, hair, bristles and wool, or in persons who had contact with infected objects. Such occupations also involve possible infection by inhalation of spores (rag disease, wool sorter's disease). Less frequently the infection may originate in the digestive tract after consumption of inadequately heated anthracic meat. Insects may also transmit the disease.

Carbuncles are followed by generalized febrile manifestations; in unfavorable cases the patient dies under septicemic circumstances. Intestinal anthrax is expressed in the symptoms of a severe, frequently hemorrhagic intestinal inflammation, while inhalation anthrax nearly always leads to death with the appearance of bronchopneumonia, unless therapy is initiated in time. Treatment with immune serum and antibiotics is the method of choice in pulmonary and intestinal anthrax.

During the years 1871-1910, 309 persons reportedly contracted anthrax in Wuerttemberg. To this is added an undetermined number of lighter cases in which carbuncles occurred in employees of industries processing hides, hair and bristles.

Of these 309 persons, 69 died (= 22.3%). The number of cases is categorized as follows according to occupations:

in the tanning industry	115 persons
after emergency slaughter	47 butchers
	5 skinners
from agriculture	11 persons
during dissection	1 veterinarian
	7 assistants
other occupations	123 persons

In 1912-1926, 20 persons contracted anthrax in Wuerttemberg;
in 1927-1934, 51 persons fell ill, 6 of whom died;
in 1935-1955, 22 persons died.

Sources of infection, their origin and control

As evident from Plate I, anthrax has not regained the prominence attributed to it in the middle twenties. Whereas in those years the annual average was 50-60 cases, it has been reduced since 1940 to under 10, with the exception of two peaks. Since 1954 the number has been on the rise and has reached a tentative apex with 23 fatalities in 1956.

Since the influence of tanneries processing animal hides has been eliminated, other sources of infection have moved to the fore. It is principally the textile industry which processes foreign animal hair that deserves our attention since 1955. From this time on 42% of all cases are concentrated in the environment of a single factory in Goeppingen County. In addition, there is a danger of importation through foreign feeds, as happened in 1949. Finally, infection may occur via spore material which may remain viable for decades in improperly disposed anthracic cadavers.

In view of the role played by tanneries and importations of animal skins in the history of anthrax in Wuerttemberg, this factor may be classified into four chronological periods:

1. The time prior to 1875, when the tanneries for the most part processed only domestic skins and thus did not constitute a special source.

2. 1875-1925, the period during which the tanneries contaminated the whole state due to increased importation and processing of animal skins.

3. 1926-1939, the years in which countermeasures were taken, causing the number of cases to subside in spite of considerable importation of raw animal hides.

4. The present since 1940, the novel conditions of which were already touched upon.

The importation of animal raw materials from abroad is closely connected with the occurrence of anthrax. If new infective material were not reintroduced constantly, anthrax would not have risen to such prominence in Germany. This conclusion is supported by the fact that the incidence of anthrax decreased considerably when imports were discontinued during the war (see Plate I).

a) Tanneries.

When we speak of the circumstance that anthrax is particularly prevalent in places where the meadows and pastures are frequently inundated, only one explanation can be offered: The sewage of tanneries located on rivers contaminates the valley meadows during floods. Plate V presents an impressive picture of this fact.

In the carse of floods, the mud which contains anthrax spores is washed away and carried onto unundated meadows and pastures, where it contaminates the fodder growing there. The extent to which anthrax has been disseminated with impure sewage from hide tanneries, especially in earlier periods, is shown clearly in Plates V-VIII. This is true not only in the Murr valley above Backnang, the center of Wuerttemberg's leather industry, but we meet similar conditions wherever there are hide tanneries, even small home establishments. This is particularly evident on

the Echaz	below	Reutlingen
Erms	"	Metzingen
Donau	"	Tuttlingen, Riedlingen, Ulm
Nagold	"	Altensteig, Nagold
Schmiecha	"	Ebingen
Jagst	"	Ellwangen
Koersch	"	Ruit
Kocher	"	Kuenzelsau
Neckar	"	Heilbronn.

The tanneries and leather factories at Feuerbach, Zuffenhausen, Esslingen, Schorndorf and Murrhardt, which process predominantly domestic hides, do not participate in the spread of anthrax and may be ignored in this connection.

In speaking of tanneries as a prime cause of many anthrax infections, one must consider various factors which are responsible for this fact and which could be effectively attacked in the control of anthrax.

1. Import of hides. These are the carriers of anthrax spores and the actual sources of infection.

2. The occurrence and control of anthrax in the tanning industry.

3. The course of the river on which the tannery is situated.

4. Climatic conditions during individual years.

1. <u>Importation of hides</u>

Hides are defined here as imported skins of horses and cattle.

The danger of introducing viable spore material with hides is most menacing when countries are involved where the control of epizootics is unknown. Such measures cannot be expected to succeed in the enormous pastures of South America and in the steppes of Asia. For this reason imports from South America, Siberia, China, East India (especially cattle hides and goat skins), Asia Minor (especially sheep skins), North Africa and Spain must always be suspected of contamination with anthrax. These are countries which due to their climatic conditions produce mainly dry hides which may harbor spores of prolonged viability, in the event they were obtained from animals killed by anthrax or slaughtered for that reason. The salted hides from Argentina and South Africa, processed in slaughter houses under veterinary supervision, are far less dangerous, not because salt could inactivate the spores, but because predominantly healthy livestock is processed there.

It may prove fruitful to correlate importation of hides into Germany from the countries named above with the incidence of anthrax in Wuerttemberg. A comparison of Plates I and IX yields the following informative conclusions:

When the first real increase in overseas imports took place in the 1870s, the incidence of anthrax in Wuerttemberg experienced an immediate and sudden rise within 10 years (from 40 in 1878 to more than 400 in 1888). The two world wars led to a steep decline in the curve during the years 1914-1920 and 1940-1948, when imports were cut off. In these years the losses due to anthrax were an average of 75-85% smaller than in the preceding years. Nowadays, when hides are imported principally from the US, Argentina, Uruguay and from European countries, and hardly any dry hides are imported into Germany, while the influx from India, China, North Africa and Spain is very small, the import of hides no longer affects the occurrence of anthrax. However, when the apices of the "anthrax curve" prior to 1940 are studied, a correlation between import of hides and animal mortality due to anthrax is largely evident. The extent to which imports during individual years influenced the incidence of anthrax in the same year and the one following, cannot be determined from comparisons of curves and their apices, since too many additional factors are involved which cannot be expressed in curves.

Any attempt to check the dangers of anthrax in Germany must start with the importation of hides, the root of all evil.

Prussia took the first steps. Beginning with May 1925, the tanneries and leather factories of Neumuenster were allowed to process only those hides that had been tested with Ascoli's thermoprecipitation and were found to be free of anthrax.

according to Gündel (14)(1935), these tests produced the interesting result of 986 out of 500,000 (= 0.22%) hides that were excluded from processing due to anthracic contamination. Based on the degree of infection, the following sequence of origins was obtained: Argentina, Brazil, Uruguay, China, India, Africa, Europe.

An epizootiological ordinance issued for Prussia on 1 December 1934, which prescribes the testing of 10% of foreign cattle skins for anthrax, did not take effect, since the professional associations of the leather industry, having no interest in such tests, protested against it. They feared that these measures would prove too expensive, since, in addition to the cost of testing, the leather industry would have suffered losses due to delays in the manufacturing process. The proposal to test only every tenth hide must be rejected out of hand, since potentially present anthrax-infected skins could be identified only with a certainty of 10%, thus offering no effective protection against infection. Moreover, as already established in 1913 by Pfeiler and Drescher (15), the thermo-precipitation test is not necessarily reliable, since Pasteur vaccines and, especially, pseudo-anthrax strains may cause stronger precipitation than genuine, pathogenic strains.

Today this ordinance is not being discussed much; other measures have all but eliminated the danger of anthrax inherent in raw hide tanneries.

In Wuerttemberg, endangered livestock was initially protected by immunization. Thus the cattle of communities particularly exposed to infection from inundations were immunized against anthrax once a year. The problem was solved only by disinfection of tannery sewage and by river bed regulation to eliminate the danger of flooding.

2. Control of anthrax in the leather industry

Whenever anthrax-infected hides are processed in a tannery or in a leather factory, there is danger not only of human infection, but of contamination of the finished products and of the waste waters.

Most human infections take the form of cutaneous anthrax. Carbuncles appear primarily on uncovered body surfaces, on the hands and arms, on the neck and face. Workers in raw hide storehouses are endangered most. They come in contact with contaminated material during transport. This menace is being countered for decades by enlightening the worker and by cautioning him to be careful with open wounds, not to scratch himself, to wash his hands with disinfecting soap, and to change his clothes in the evening. These hygienic measures, increased mechanization and stepped-down import of anthrax-infested material have made human anthrax in tanneries a rarity.

Since the methods used in the processing of hides generally have no sporocidal effect on anthrax, there is a possibility of infection from finished products. While no such cases have been reported recently, it is recorded that two hourses contracted anthrax around the turn of the century from new harness made out of a tanned "anthracic hide."

The danger of anthrax-infected waste water is still acute, particularly in agriculture. Large numbers of spores adhering to the skins reach the water used in softening; frequently we find fully virulent spores in the tanner's pit and in the waste water of the tanning process proper. When this tannery sewage is conducted to the main canal without prior neutralization, there will always be repercussions, since anthrax frequently occurs on meadows located on the river below the tannery.

Thus the first problem involves sewage. Various hindrances are encountered here, since the technical means for adequate waste water purification do no exist and no clear legal instrument is in effect which would cause the leather industry to take necessary steps. Although paragraph 17/15 of the epizootic law prescribes "regulation of removal or purification of water waste and refuse from tanneries, fur and hide shops," but no ordinances have been issued in this sense. The leather industry solves this problem as simply and cheaply as possible; the smaller tanneries in particular act irresponsibly and thoughtlessly at times by letting their sewage run off into canals or creeks without treatment of any kind, usually under cover of darkness. When the stream is contaminated in this manner, no serious consequences may ensue for years, but whenever anthracic material is processed and the spore-containing mud is carried onto the meadows, these abuses become apparent.

There are 2 theoretical methods of disinfection: Either the hides are decontaminated before or during processing, or the resultant sewage is purified. Sometimes this takes place within the establishment, but usually there is a collective purification plant to which the community and the whole industry are connected.

Destruction of anthrax spores on infected skins by means of chemicals is difficult, since spores are very resistant and the bacterial protein must be denaturized without harming the skin's protein. Hailer and Heicken (16) are presently dealing with this problem. It must be remembered that laboratory tests utilizing freely suspended spore material cannot be compared with practical conditions; in the latter case the spores are not exposed directly to the effect of chamical substances, since spores may be hidden in pores or fissures and may be protected by organic material.

Disinfection of hides during the softening process would be most practical, but the ideal disinfectant has not been found to date. It should disinfect rapidly and completely with adequate penetrating and wetting power, without impairing quality, and should be applied simply, safely and cheaply. In view of these stringent requirements, it was necessary to compromise and to accept this or that unpleasant property.

As reported by Hausam (17), chloride of lime has been suggested as an additive to the softening water, but this method is too uncertain, since the concentration of chloride of lime fluctuates; besides, halogens are injurious to the skin at the required concentration.

Admixture of sublimate leaves spots of mercuric silver sulfide, hydrogen rhodanate has no penetrating power, slake lime and sulfide pits are not sporocidal enough. Many things were tried, but nothing found practical application.

Among inorganic disinfectants, socalled pickling has given the best results. This involves a preliminary process in chromic tanning which has a sporocidal effect at the following concentrations, as prescribed by the Federal Health Department:

I. 10% NaCl + 2% HCl at 20°C for 40 hours
II. 10% NaCl + 2% HCl at 40°C for 9 hours
III. 10% NaCl + 1% HCl at 40°C for 15 hours.

Method I is best suited for preservation of quality and usually suffices for thin hides. Thick and fat cattle hides are not disinfected positively. If pickling is prolonged, the surface becomes slightly tanned. In the case of heavy soles, this entails undesired pre-treatment and impairment of quality.

A positively sporocidal concentration of such organic disinfectants as formalin, phenol and cresol again causes slight superficial tanning; the hide does not swell properly and cannot be depilated as usual. Besides, phenol and cresol are poorly water-soluble; their antiseptic effect is largely neutralized by fats. A solution of toluolsulfodichloramide in carbon tetrachloride has a satisfactory disinfectant effect, but is feasible only for a small number of skins due to its high cost.

It is not known how well crude zephirol would work in practice. Hausam recommends it; an 0.5% concentration applied for 24 hours at 20°C is said to have a strongly inhibiting or even lethal effect on anthrax spores adhering to organic material. It has excellent wetting powers and is harmless to the hands; the pit must nevertheless be sterilized as an additional measure, since living organisms are occasionally found therein. Finally, there is the method of biological disinfection. The technique is based on the premise that the vegetative form of anthrax bacilli is more readily killed than spores. The latter are therefore induced to germinate by submersion in water for 48 hours at 43-44°C. There is a possibility, however, that the hides begin to rot or that they are harmed by excessively high temperatures. The vegetative form of the bacillus is then inactivated for 24 hours in slaked lime. This process is very troublesome and difficult; it is too expensive and uncertain, and has no practical value.

Aside from pickling, the methods of chemical disinfection of hides and sewage during processing have not been accepted by Wuerttemberg's leather industry due to their high cost. If the menace of anthrax is being controlled at all by the tanneries, this occurs only in existing purification plants.

It is known that two leather factories, those at Ellwangen and Bopfingen, possess their own sewage purification installations. These consist of simple settling basins in which most of the mud is captured. Obviously this does not represent adequate disinfection. In most cases we find common interests between community and industry who have built collective purification plants with assistance from the state.

The purification facilities of the Sewerage Association of Backnang, built in 1935, have long been considered very modern and pioneering in the field of waste water decontamination. In addition to community sewage, the plant collects and purifies all industrial waste waters and those from the large leather factories. Great trust was placed in this installation and it was hoped that it would eliminate the danger of anthrax. However, a glance at the comparative maps of the years 1909-1957 (Plate II-VIII) reveals that the incidence of anthrax has abated noticeably in the region of the Murr, but that the counties of Backnang, Ludwigsburg and Heilbronn still belong to the most infested areas of Wuerttemberg. A number of cases would be caused by viable anthrax spores introduced prior to 1935, but, at any rate, this purification plant no longer meets the requirements placed on sewage decontamination today.

The plant is a purely mechanical water purification installation with a capacity of 150 l/sec. It is utilized almost at capacity on a daily average. The water is supplied by the households (5%), the textile and metal industry (15%) and the leather factories (80%). After passing through a rake and a sand trap, the water is led through two settling basins at 20 cm/min, where 95% of the insoluble components precipitate. About 150 tons of mud (containing 95% water) are settled out per day. It is pumped without further treatment to a mud lake. The purified waste water, together with the remaining insoluble 5% and all dissolved organic and inorganic components, then flows into the Murr River. Although the effectiveness of this purification plant is high (a large percentage of viable spore material is probably withheld with 95% of insoluble components), it is still inadequate, since the sewage is not cleansed satisfactorily and the spore material is not captured in sufficient measure. In practice, these works do not even approach the conditions under which anthrax-infected wastes may be rendered harmless.

This would become apparent as soon as the leather factories start processing anthrax-infected hides. At present the high dilution factor has a very favorable influence. As long as spores do not collect in high concentrations in the river bed, but are rushed along into the Neckar, there is no direct danger.

As reported by Hausam, biological purification of mechanically pre-cleaned sewage makes it nearly sterile. Bacteriological studies, specifically of anthrax, at such a plant serving raw hide tanneries gave a positive anthrax identification once

in 19 cm^3 of unpurified tannery sewage
in 31 g of mud from the 1st settling basin
in 2 g of activated sludge
in 11 g of sand filter layer
in 125 l(!) of purified waste water.

No progress has been made in this direction at Backnang due to the high percentage of industrial wastes (95%). Their composition of such chemicals as sodium sulfide, chromium salts, alkalis, phenols, formic acid and others makes biological purification impossible, since the living conditions are too unfavorable for putrefactive bacteria. lower fungi, algae and protozoa, and dissolved, decomposable contaminants cannot be digested and mineralized. A ratio of 60:40 between household wastes and tannery sewage is favorable for biological purification, 50:50 is just supportable.

Precipitation of 5% undissolved contaminants with ferric (III) salts failed at Backnang; this method undoubtedly would have captured a large share of microorganisms. Nowadays the only promising method involves purification by mechanical filtration. However, the cleaning of filters is so difficult that all attempts have failed -- the filter become clogged in a short time.

Aside from Heilbronn and Goeppingen, Ebingen's leather industry utilizes a collective mechanical purification plant since 1936, that of Reutlingen since 1954. The incidence of anthrax had been high for decades in the region of the Schmiecha and Echaz rivers below Ebingen and Reutlingen. Plate VIII shows that the danger is still real today, although not as acute as it was prior to the construction of these works.

The purification works at Ebingen, which also serve the communities of Oustmettingen and Tailfingen, have been in need of enlargement for several years, as the capacity of 150 l/sec is taxed by an average of 320 l/sec. This means that the waste water passes through settling basins more rapidly and deposits only 92-94% of insoluble components. The plant will be enlarged and supplemented with a biological purification apparatus in the next few years. As in the case of Reutlingen, such an installation is made possible because the share of industrial waste is not greater than 40%. Another remarkable facility is the treatment of sludge in decomposition tanks at Ebingen and Reutlingen -- resulting in up to 800 m^3 of methane per day — and its sale to agricultural users after air-drying. Fertilization with sludge has never led to an outbreak of infectious diseases, although the material is not sterilized with quicklime or by other means.

A biological purification plant is being built at present in Murrhardt, designed to include a leather factory among its customers. However, there are still several smaller establishments at Metzingen, Kemnat, Nagold and elsewhere, whose sewage is not being cleaned at all.

Disinfection of tannery wastes could be accomplished by methods other than purification, but these processes are uneconomical and usually unreliable. Waste water could be heated for two hours at 100°C in the presence of 2% chloride of lime or formaldehyde.

Since anthrax spores are more resistant to the antagonistic potential of coli and other bacteria than the vegetative form of the bacillus, Gillissen (18) recommends that the spores be induced to germinate by a favorable nutrient composition, sufficiently high temperatures and an adequate oxygen supply. This would take 10 days, provided the aforesaid conditions exist. Since no purification plant has basins of this size (water is normally clarified in 1½ hours), this process cannot be used in practice regardless of its complexity and unreliability.

3. The main sewage canal.

The danger of anthrax from tanneries depends on the course of the river on which the establishment is located. This is particularly true of the time before 1935, when the tanners still passed their wastes directly into the creek. This correlation is still evident today, as reflected by Plates V-VIII, since not all purification works guarantee complete decontamination and disinfection. Two examples will explain this situation.

Although Heilbronn is a center of the leather industry, anthrax never occurred as frequently below this city as it did below Backnang. In the first instance we have the Neckar, a river whose rapid waters carry off most of the mud and which seldom leaves its banks due to early canalization. The other river, the Murr, winds gently through the meadows and inundates the pastures from time to time. While the sewage is strongly diluted and cleaned in the Neckar, the Murr is unable to serve this purpose and sludge is deposited because of the slow rate of flow. This was the case particularly before the purification plant withheld 150 tons of sludge daily. Although the Murr has been straightened near Burgstall and above Backnang, wide areas of the valley are flooded as before, especially in the region os Erbstetten, Burgstall, Kirchberg, Erdmannshausen, Steinheim and Murr (cf. Plate VIII).

As proved by the floods of March 1956, the danger of flooding is just as acute today as it was 50 or more years ago. Melting snow or prolonged rain may cause Wuerttemberg's rivers, including the Donau, Jagst, Rems, Murr, Schmiecha, Echaz, Kocher and many others to leave their banks. Usually this would not constitute a major menace; there are no plans to regulate these river beds in every instance, since this would cause the ground water level to fall and would interfere with the water supply of many communities. It is only when tanneries are located on the stream that deposits of anthrax-infected mud may introduce the disease.

4. <u>Influence of weather conditions</u>.

As we have just established, certain areas are menaced by anthrax among livestock in the wake of floods. Floods usually occur in years of increase precipitation. It would be interesting, therefore, to study the correlation between total precipitation and the incidence of anthrax in a given year.

Comparison of the curves in Plates I and X indicates clearly that there is indeed a connection between these two factors. Thus the unusually humid year

1922	was matched by a high incidence of anthrax in	1923
1925	"	1925
1927	"	1928
1931	"	1931/32
1935	"	1935;

while the dry year

1921	was followed by less anthrax in	1922
1923	"	1924
1926	"	1926/27
1928/29	"	1929/30
1933	"	1933/34.

The connection is not as clear in the time prior to World War I. While the correlation cannot be established during the years 1892, 1896 and 1906, the year 1900/01 does not fit the picture at all. This indicates that epizootics are governed by so many additional factors that their course cannot be predicted on the basis of a few facts. Yet, without a doubt, a higher incidence of anthrax could be expected in humid and rainy years when compared to dry ones. This statement applies only to the time up to the middle of the 1930s; the situation is entirely different today.

Plate XI gives a monthly distribution of anthrax in 1898-1908. Two distinct peaks are apparent, one in spring and another in fall; the number of cases abates in summer. This observation is contrary to the general opinion that anthrax is a summer disease. In areas where contaminated waste water infects flooded meadows and pastures (this applies to Wuerttemberg especially before 1935), anthrax occurs most frequently at the time when green fodder is given and in fall and winter, when hay obtained from these meadows is fed to the livestock. The incidence is lower in summer, when the animals are fed clover, alfalfa, mixed feeds, turnip leaves, etc. Moreover, cattle are usually kept indoors in Wuerttemberg. The picture will be quite different in countries where cattle are raised principally on pastures; there one can definitely consider anthrax a summer disease.

Computation of the "statistical anthrax year" from 1 April to 31 March (from the start of green feeding to the end of winter feeding) offers a better idea of the real epidemiological events. This permits compilation of those cases of anthrax that are caused by special weather conditions of a certain year. It also explains why the peaks of the anthrax curve (Plate I) are often displaced by one year compared to the amount of precipitation (Plate X).

If, moreover, a correlation exists between atmospheric temperature and the incidence of anthrax, such a dependence is not evident from a comparison of annual morbidity and average yearly temperatures, since it does not give enough clues to the actual climate of the year in question. The maxima and minima of these curves do not agree often enough (only in 60% of the cases) to be informative; the average of 1890-1938 shows, however, that anthrax is slightly more prevalent in warm years than in cold ones.

b) Foreign animal hairs.

While the danger of anthrax-infected sewage from the leather industry is in the process of gradual abatement, another field of industry has suddenly gained prominence since 1955 as a source of new eruptions. These involve the textile industry which processes foreign hair, bristles and wool.

Since October 1955 we find a higher incidence of anthrax, particularly in Goeppingen County; aside from isolated cases there were 7 bovine fatalities within 3 months. A county in which anthrax was barely known in the past (see Plate II-IV) became the unsuspected focus of this disease. While the average annual loss in Wuerttemberg since 1950 amounted to 6 animals, the total for 1955 rose to 19.

Investigations ordered by the State Veterinarian determined that the region utilizes the refuse of a hair-processing firm in Ebersbach as fertilizer. The farmers and gardeners obtained this hairy fertilizer and spread it on their fields and meadows. The custom had been successful for many years and never produced undesired results until now, when anthrax suddenly occurred all around Ebersbach, raising the suspicion that its cause may be found in the fertilizer.

A check with the manufacturer disclosed that foreign hair is rarely, if ever, disinfected prior to processing, and that cutaneous anthrax had often occurred among the workers. This was very interesting, but bacteriological studies made by Rau (19) for a dissertation gave the surprising and informative result that 23% of all samples of raw material contained anthrax spores. Sixteen of 27 samples of Chinese goat hair were positive (60%), 3 of 12 (25%) from Iraq and 2 of 8 (25%) from Morocco. Of 19 samples of South American goat hair, 1 was positive, as was 1 sample of wool among 8 from Pakistan. No anthrax spores were found in raw materials from Mongolia, South Africa, Algeria and Italy.

This investigation shows the importance of measures for the control of anthrax in the industries which process hair and wool. The danger does not only exist in Goeppingen County, where these signs are most evident; time and again anthrax carbuncles crop up among the workers of such establishments, as was the case in August 1956, involving a carpet factory in Weil-der-Stadt. As early as 1909, five farms in Kirchheim County reported anthrax after their meadows and fields had been fertilized with foreign wool by-products and horse hair. One farm at Bartenbach (Goeppingen) lost 2 head of cattle in October 1955; it was found that a nearby nursery had obtained hairy fertilizer from a horse hair spinning mill at Mannheim. Anthrax spores probably had been washed on the pastures of the affected farmer by rain water.

In England such happenings have been prevented for some time by routing of all imported animal hair through Liverpool and immediate disinfection thereat. This is done by vacuum-steam disinfection with formaldehyde-water steam. I do not know whether similar steps are taken at Hamburg and Bremen, but it seems that no adequate measures are in effect in Germany which would protect man and animal against infection with anthrax.

The Ebersbach firm has meanwhile installed its own disinfection facility. The entire raw material is sterilized by steam at 105°C and 0.15 atmospheres overpressure on a slowly moving grate for 40 minutes. Quality may suffer when the hairs become curly or yellow, and when their elasticity is lost due to brittleness in the ends.

As long as no measures are taken at a high level, this is the best method of controlling the disease, provided the disinfection facility can handle the entire volume of foreign material.

As the epidemiological events of 1956 and 1957 show, fertilization with hair by-products from this firm has created a focus of anthrax in Ebersbach, Goeppingen County, which will lead to new outbreaks of anthrax in the future, since the disseminated spore material cannot very well be made harmless.

c) Foreign feeds.

It is difficult to determine the number of cases attributable to infection with foreign supplemental feeds. 22 cases were reported in Wuerttemberg during 1925-1951, in which anthrax had occurred after feeding of imported fodder.

In 1927 a pig died in Stuttgart-Hohenheim after consumption of Argentine meat meal; in 1934 three head of cattle from a farm in Adelmannsfelden (Aalen) were reported to have expired after feeding on linseed cake meal. Since suspected cases usually cannot be confirmed by bacteriological studies, it is possible that a number of unexplained cases of anthrax are attributed to this cause.

Since 1949 the Wuerttemberg State Veterinary Inspection Service has examined 25 samples of imported oil cakes, animal meal, fish meal, fine meal and similar feed mixtures. Anthrax could not be demonstrated either culturally or in animal tests. It must be remembered, however, that methods in use heretofore did not guarantee positive diagnosis. For in 1949, when anthrax occurred in various places throughout the state, especially in Aalen County (see Plate IV), which was definitely ascribed to the feeding of foreign oil cakes, anthrax spores could not be demonstrated in this fodder. Ninety tons of Italian oil cakes had been imported at the time and were distributed through agricultural associations. Shortly thereafter the incidence of anthrax rose, involving 9 head in Wuerttemberg alone, and 13 in Hessen (see Plate I). Investigations disclosed that the oil cake had been made of Brassica and showed heavy contamination with animal hairs. These had adhered to the fodder during marine transport in close contact with dried skins. Since the oil cakes were stored throughout the state, their collection and destruction was quite cumbersome. Compensation of purchasers was an additional complication.

Although this is the only recent case in which anthrax was introduced with a supplemental feed, caution is indicated for the future, since this manner of infection is always possible. Since there are no guarantees that would assure the hygienic processing of such feeds, it is important that the contamination of foreign feeds be discovered.

No correlation was established between the amount of meat meal, bone meal and fish meal imported into Germany, and the incidence of anthrax in Wuerttemberg.

d) Animal burial grounds and cadaver processing plants.

Although most outbreaks of anthrax are traced to foreign raw materials, we must not forget that sources of infection exist within our borders. Nowadays animals afflicted with anthrax may be slaughtered only in exceptional cases; hardly any spores escape destruction by the method of decontamination in current use. Conditions were different in the past. Cadavers turned over to the flayer were withdrawn from the trade and kept apart from other susceptible animals; processing of cadavers in the flayer's yard was not aimed at total destruction of organisms, however.

Until recently, cases of anthrax have been traced to fodder grown on one-time animal burial grounds. In 1955-1957 one farm in Harlazhofen (Wangen) reported anthrax in 1 horse, 1 bull, 3 cows, 1 hog and 1 cat after the livestock had been fed hay grown on an old burial pit. In 1952 a cow succumbed under similar circumstances in Fichtenberg (Backnang), although the last anthracic cadaver had been buried there more than 30 years ago. Similar cases occurred in 1925 and 1931 at Flein (Heilbronn), in 1930 at Heselwangen (Balingen), where in the course of 3 years five cases of anthrax were attributed to an old burial ground.

As a rule the various communities have no record of past burial grounds and frequently use them in farming or construction, instead of fencing them in and planting trees. This situation continues to lead to mysterious cases of anthrax, either by procurement of feed containing spores or by excavation of soil infected with an anthracic cadaver and dissemination of spore material in this manner.

Such soil infections are easily brought about with old methods of cadaver elimination in flaying yards or on separate community burial grounds (20). Flaying of cadavers was the general custom; removal of cattle and horse hides was considered dangerous, while the flaying of anthracic sheep was deemed quite harmless. The inner surface of the sking as well as the exposed areas of the subcutis and musculature were permeated with anthrax bacilli; adequate humidity, warmth and access to the atmosphere enable the spores to develop. The spores have shown apparently unlimited viability — at least when dried on silk threads — while vegetative cells in the closed animal cadaver are quickly killed by putrefaction. It is certain that very large numbers of anthrax spores were left in burial pits. It is interesting to note that "anthrax may disappear from regions and localities where it has been endemic for many years" (21). It is possible that spores do not remain viable indefinitely in the soil and do germinate; the bacilli can then be destroyed by antagonists (antibiotic effect). Spores of the anthrax bacillus may remain viable in the soil for prolonged periods; the duration of such soil contamination is not entirely unlimited.

Since the clover farm Cannstadt, the last establishment of this kind in Wuerttember, was closed on 31 March 1920, this problem is no longer acute. The removal of animal cadavers was regulated by an ordinance of the Medical College dated 26 April 1918. Based on the flaying code of 31 January 1917, the state's communities are assigned the following five animal cadaver processing plants: Sulzdorf, Kleinsuessen, Kornwestheim, Horb and Biberach. Wuerttemberg had thus taken measures which constituted a major advance in the control of animal diseases. The steady decline in the annual incidence of anthrax must certainly be credited to this fact. Before that time, every community was obliged to furnish a public cadaver burial plot, as prescribed by the flaying law of 17 June 1911, unless a flaying facility was located within a radius of 50 km. A separate section was reserved for animals infected with or suspected of anthrax. The law permitted burial as a method of elimination, provided a high ground-water level did not prevent this, in addition to neutralization by intense heat or by chemical means. Since the end of 1918, all five animal rendering plants have become operational in Wuerttemberg. The cadaver removal law of 1 February 1939 provides for treatment with intense heat in order to kill pathogens of transmissible diseases and to procure products of economic value. This applies to all cadavers with the exception of those listed in paragraph 4 (dogs, piglets less than 6 weeks old, lambs and kids).

The cadaver removal facilities of Wuerttemberg reverted to state control on 1 September 1921. Their total turnover in 1924 was 3,000 large and medium cadavers, of which 10% were diseased animals.

e) Farms with high incidences of anthrax, and legal regulations for its control.

Improper elimination of anthracic cadavers, emergency slaughter of animals suspected of or infected with anthrax, and violation of even the most primitive requisites of disinfection have in the past produced sources of infection in a stable or shop that later claimed additional victims.

Thus, for example, one farm at Doerrenzimmern (Kuenzelsau) reported 5 fatalities due to anthrax within a few years, after 2 anthracic animals had been slaughtered in the same stall in 1931. A farm in the village of Wendelsheim (Rottenburg) was long considered a focus of anthrax. Investigations disclosed that a number of cadavers had been buried nearby during Napoleon's campaigns. That these really were the cause of outbreaks seems rather unlikely in view of the span of 150 years, but this case demonstrates how far in the past one must occasionally search for clues to new infections. In the spring of 1956 a cow contracted anthrax in Eislingen (Goeppingen). The search for its cause was unsuccessful until an old butcher recalled that the stall had been used as an emergency slaughter house in the past. Flood water of the Fils river had recently entered the basement and had inundated turnips stored there.

It is possible that spore material had been washed onto the turnips from cracks and crevices. Additional foci of anthrax are found in farms near Eschach (Ravensburg), Ellenberg (Aalen) and Herbrechtingen (Heidenheim).

Since precise rules have been issued in the animal disease law of 26 June 1909 and its implementation instructions (22/23) for action in the case of epizootics, there is no danger that new sources of infection can be created in similar instances.

It is very important that no one except veterinarians dissect cadavers infected with anthrax or symptomatic anthrax, as required by law, and that animals infected with or suspected of anthrax are not sacrificed (par. 98, 99, 106). Cadavers must be secured; flaying is prohibited (par. 95, 101/II). The milk, hair, wool, cadavers and cadaver parts (meat, skins, blood, entrails, horns, hooves, etc.) must be eliminated safely (par. 100, 101). Stables and stalls must be disinfected; persons in contact with cadavers or sick animals must also submit to disinfection (par. 105).

When the danger of an epizootic is acute, the police may order immunization of animals susceptible to anthrax (par. 104). The cattle of farms on which anthrax had appeared within the past 2 weeks must be subjected to Sobernheim's inoculation (passive and active immunization), those of other endangered farms to Pasteur's active immunization. These methods have been very effective in Wuerttemberg for nearly 50 years in all those cases where no other control measures were feasible. Even before World War I, the livestock of entire communities was successfully immunized in areas where hay from flooded meadows was being fed to cattle.

Summary

Although anthrax caused great losses among cattle in Wuerttemberg prior to World War II, its importance has abated since the beginning of the 1930s. Today ~~its role~~ is limited to foci in Goeppingen and Ludwigsburg Counties, and to isolated cases throughout the state.

As seen especially well in the Murr valley, the communities situated on rivers below tanneries were menaced by spore-containing sludge from tannery sewage, which was carried to valley meadows and pastures during floods. Since almost no anthrax-infected raw materials have been processed by these tanneries after World War II, this danger has been largely eliminated. The construction of purification plants at Backnang, Ebingen and Reutlingen, as well as river bed regulation, have had a favorable effect, although these measures cannot always protect man and beast against infection. No method has been found to date that would disinfect hides before or during tanning and would decontaminate the resultant waste water cheaply and without harmful effects.

At present, the main danger threatens from the textile industry which processes foreign animal hair. Since the by-products of this industry are sold as fertilizer, new infective material is continually brought onto arable land. This practice must be stopped at all costs as long as adequate disinfection of the material cannot be warranted. The entire import of foreign animal hairs should be disinfected centrally after unloading, as is being done in England, because experience teaches that decontamination during processing is not carried out with sufficient vigilance.

In addition, there is the danger of introducing anthrax in foreign feeds, as shown by isolated outbreaks. This menace is usually exaggerated; still, the bacterial count should be determined at least in spot tests, particularly when animal meal and bone meal from South America, South Africa and the Near East are involved.

Legislation governing epizootics has effectively dealt with the danger of dissemination following such outbreaks, aided by cadaver processing plants which have been operating successfully for 40 years. Since anthrax spores remain virulent for extended periods under favorable conditions, the negligent manner in which anthracic cadavers were disposed of in the past continues to be a matter for concern.

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